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Rising Above the Problem

Two hundred years ago this year, Meriwether Lewis and William Clark lead the Corps of Discovery on a very long and difficult journey to explore the unknown wilderness in the northwestern United States and the Oregon Country. They were looking for a water way that would allow ships to travel all the way from the Atlantic Ocean to the Pacific Ocean. They followed the Missouri River as far as they could, but when they finally came to a fork in the river, they were at a loss to know which way to go. Whenever possible, one of them would climb a mountain to get a better view of what lay ahead. But they could never see far enough to be certain of the best route.

If only Lewis and Clark had been able to raise that mountain a few hundred miles higher they could have saved themselves and their team a lot of cold, wet nights and blistered feet!

"Lookout Towers" in Space

Now we have Earth-orbiting satellites that not only give us the big picture of where the rivers flow and the mountains stand, but also give us such detailed, sharp images of Earth's surface that even the eagles soaring over the trudging Corps of Discovery would have been envious of the view.

Because of our remote sensing technology, we now know the terrain of Mars far better than anyone knew the terrain of the United States 200 years ago! Knowing the terrain of Mars is certainly very fascinating, and may someday help us understand the origin and history of our own planet. However, putting spacecraft in Earth orbit with their imaging instruments pointing downward is giving us a different kind of knowledge that we can use to solve everyday problems right now.

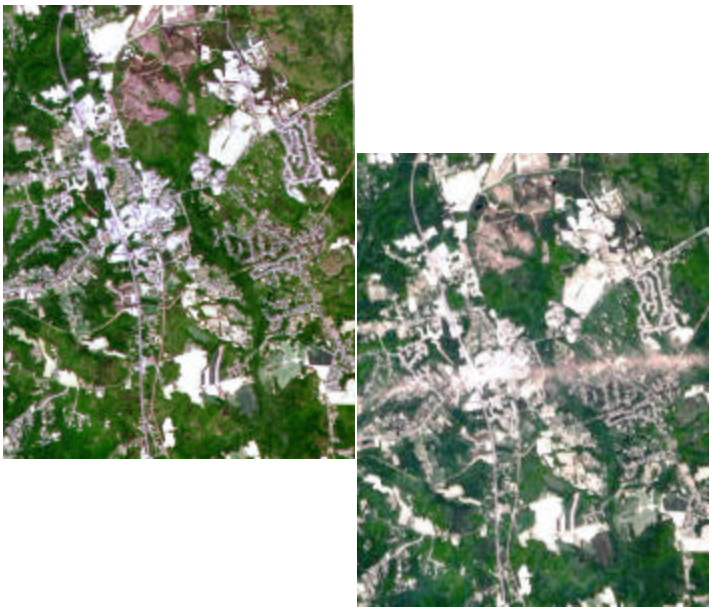
Worth More Than a Thousand "Pictures"

If a picture is worth more than a thousand words, as the saying goes, what we get from Earth imaging spacecraft is worth more than a thousand pictures. Spacecraft such as the Landsat satellites have provided an enormous amount of data since the early 1970s. The instruments on these satellites gather far more information than any camera just taking "pictures." For example, there are instruments that sense light human eyes cannot see (such as infrared), and can make very fine distinctions among different colors of light to reveal details of conditions and events on the ground. A forest might just look like a big blob of green to our eyes, but to a "hyperspectral imager" would appear to be many different shades of green, indicating different types of trees or perhaps areas where trees are diseased.

The data gathered by these satellites is stored in giant computer databases and is available for all kinds of scientists, map makers, agricultural planners, forest managers, city planners, and other protectors and managers of Earth's resources to use in whatever way will help

All these images were made using data from advanced technology instruments flown on the Earth Observing-1 spacecraft.

At the left is the island of Oahu, Hawaii. Below shows Pearl Harbor. Even though taken from more than 500 miles up, the image clearly shows a plane sitting on the runway!



The above images are of La Plata, Maryland, before and after a tornado swept through April 27, 2003. It was the strongest tornado in Maryland history, carving a swath of destruction 26 miles long and extending from 50 feet to more than 400 feet wide in places.

them do their jobs. And not only is the data available, it can be processed in such a way as to bring out the details that are most important to the particular user of the data. For example, if someone wants to study the distribution of different species of trees in the forest, the differences in the shades of green in the forest can be exaggerated so that the pine trees are purple and the maple trees are red!

Here are a couple of examples of how remote sensing data might be applied.

- **Urban Planning:** A land developer wants to buy a large tract of undeveloped land on the outskirts of a large city for the purpose of building hundreds of new homes. The area he is considering is near a beautiful, serene river, which he feels will be a great selling feature to offer prospective home buyers. Although the river looks quite friendly and harmless now, he knows that a few years ago when nearly twice as much rain fell as normal, the river overflowed its banks in a few places. It's not obvious now, though, where those places were or how far the flooding extended. He decides to take a look at some satellite photos taken during that period of flooding to find out exactly where the trouble spots were so he can plan to put parks in those place instead of homes.
- **Atmospheric science:** A team of scientists and planners (meteorologists, atmospheric chemists, environmental policy analysts) want to understand whether Earth's climate is changing and whether any increases in global temperature can be correlated with loss of tropical rainforests. They need a reliable way to measure how much rainforest has disappeared over a 15-year period. They obtain satellite imagery of the rainforests of South America over the past 15 years. The images clearly show changes in the rainforest, farmland, bare ground, cities, and bodies of water. By comparing the images from one year to the next, the team can measure the exact rate at which the forests were destroyed and include that information in their calculations and conclusions.

TAKE A DUNK IN THE THINK TANK

In this activity, you will have a chance to dream up your own Earth surface scenario and take a look at it in your mind's eye from over 500 miles up! Keep in mind that there are no right or wrong answers in this thought experiment.

1. Divide the class into groups of 4 or 5 people each. Each group will be a "Mini-Think-Tank" team charged with proposing new ways to use Earth remote sensing data.
2. First, each Mini-Think-Tank will choose a type of problem from this list:

   Volcano

   Earthquake

   Flood

   Drought

   Urban planning (can include any of the other problem types)

   Farming (agriculture)

   Map making

   Forest fires

   Forest diseases

   Erosion of beaches

   Melting of polar ice sheets

   Oil spill

   History of asteroid impacts
3. Brainstorm to invent a problem scenario. Use your imagination! Now, think of how a great view from way up above the ground can contribute to your understanding and help to define or deal with the problem.
4. Money will be needed to buy Earth imaging data and to pay people to process and analyze it. Outline a request to a concerned organization (like a department of national or local government, or a large company) for funds to use high-resolution, custom processed satellite images to define the situation. Propose how the images can be used to deal with it. Companies and governments receive many requests to fund all sorts of projects, so you will need to make a good argument for your ideas. Here are some questions to consider:

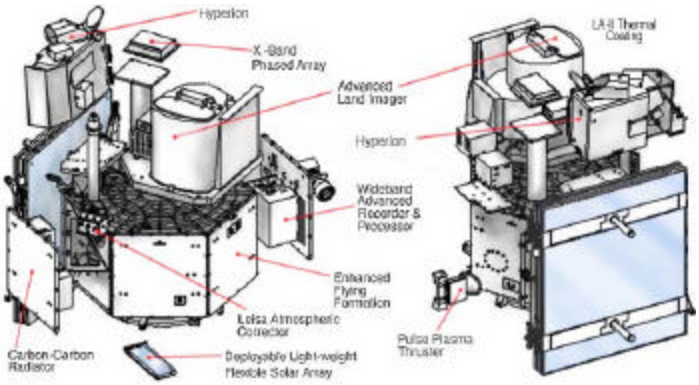
- Is this a problem in which people's lives might be in danger (such as from an erupting volcano or a flood)? If so, can you explain how and make a very strong argument for funding your study and funding it quickly?
- Is this a study of long-term trends in the environment or in human impact to an area? Is there danger that the trend could produce a harmful result? Is it known when, where or how? If not, can you make a case for the importance of understanding the changes as soon as possible so that something can be done?
- If your request and proposal is to a private or public business, could the study potentially improve the company's profits or public image? If it's to a government body, what advantages might be seen by taxpaying voters?
- If the study is purely to contribute knowledge about Earth, is it really important? Could the knowledge gained be combined with information from other fields to enhance our understanding still further?
- For what time period and geographical location will you need data for your proposal? Do you need all the data available for your time period, or will a sampling do? (For example, if the satellite has passed over your area of interest every 16 days, do you need data from every pass or would, say, four passes for each year do the job?)
- What sort of processing is needed for the data? In other words, what details in the images would you want to be able to detect quickly? We gave the example of the different kinds of trees in the forest. Another example might be to enhance the urban areas (pavement, buildings, etc.) with one color and the green areas with another. Push the limits! For your proposal, can you imagine automatically enhancing details that could tell you even more? Details like people, polar bears, power line wires, chocolate, lava rocks, bicycles, etc.?

5. As a team, present your ideas to the rest of the class.

EVALUATION QUESTIONS??

PUSHING THE LIMITS—MAKING TECHNOLOGY EVEN BETTER

A special satellite called Earth Observing 1 (EO-1) was launched in October 2000 to test some new technologies that will even further improve the quality and usefulness of the data that future Earth-imaging spacecraft will be able to provide.



This sketch of the EO-1 spacecraft shows the placement of not only the three imaging instruments using advance technologies, but also several other new technologies that were flown in space for the first time.

Earth Observing-1, launched in November 2000, has completed its primary technology validation mission and is now being re-programmed to test advanced new software for greater automation and efficiency in gather imaging data.

The new imaging instruments that EO-1 tested are:

- Advanced Land Imager—Images the ground as well or better than the imaging instrument on the latest Landsat satellite, but is smaller, lighter, and more energy efficient.
- Hyperion—This is a new type of instrument that is extremely sensitive to differences in the color of light it is sensing, so from its data scientists can actually tell a pine tree from a maple tree—from space!
- Atmospheric Corrector—Like a fogged up window clouds the view on the other side, the atmosphere clouds the images of Earth taken from space. An Atmospheric Corrector measures the amount of water in the atmosphere and estimates how much it affects the amount of light being reflected from Earth's surface.

All the new instruments tested on EO-1 have proven to work well, so their technologies can be used to make future Earth observing satellites even more useful and efficient. EO-1 and all the different new instruments it carried are part of NASA's New Millennium Program, whose purpose is to test out new technologies in space, so that they can be used reliably on future space missions. In the case of EO-1, the new and better data these technologies will provide will help us understand the complexities of how our planet works and how to take better care of it and ourselves.

Visit The Space Place at **spaceplace.jpl.nasa.gov/eo1_1.htm**, and learn more about EO-1's Hyperion instrument and how it can sort out the trees in the forest

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